REMARKS

I. Allowable Subject Matter

Applicant is appreciative of the Examiner's indication that claims 4, 6, 7, 8/6, 9/8/6, 10/9/8/6, 11/4, 111/6, 11/7, 12/11,4 12/11/7 represent allowable subject matter if re-written in independent form including all of the limitations of the base claims and any intervening claims.

For the reasons set forth below, Applicant submits that all of the pending claims, i.e., claims 1-18 and 27-29, are allowable.

II. Claim Rejections

On page 3 of the Office Action, the Examiner states that the claimed invention directed to the combination of an ion selective membrane, e.g., a nanofiltration ("NF") membrane, and a thermal distillation system, e.g., multistage flash distillation (MSF"), multi effect distillation ("MD") or vapor compression distillation ("VCD"), is patentable. The Examiner has acknowledged the advantageous effect of the claimed method, i.e., introducing a feed of variable proportions of softened and untreated water, on increasing the top operating temperature of such thermal distillation systems.

However, the Examiner states that Applicant has not been persuasive with respect to the advantageous effect of the claimed invention on increasing the top operating temperature of a combined ion selective membrane, e.g., NF membrane, and a reverse osmosis ("RO") system. In this regard, the Examiner relies on US 6,113,797 to Al-Samadi ("Al-Samadi") and WO 99/16714 ("Hassan") to support an obviousness rejection under 35 U.S.C. §103.

For the reasons set forth below, it is respectfully submitted that the Examiner has not established a *prima facie* case of obviousness.

A. Al-Samadi

Claims 1-3, 5, 8, 13-18 and 27-29 are rejected under 35 U.S.C. §103(a) as being unpatentable over Al-Samadi. In brief, the Examiner alleges that Al-Samadi discloses the claimed process of softening a stream of water with an ion selective membrane, e.g., a NF membrane, and blending the softened stream with a stream of untreated water to form a variable feed to a desalination unit, e.g., RO, to increase the top operating temperature of the RO membrane unit.

1. Al-Samadi does not suggest the steps of the claimed process.

As demonstrated in the following paragraphs, Al-Samadi does not suggest the steps of the claimed process.

a. The first step of the claimed process:

> A desalination process to produce potable water which comprises:
> (a) passing a first stream of water containing a high concentration of hardness ions through an ion selective membrane to form a softened water having a reduced content of hardness ions;

Step (a) of the claimed invention requires the use of an ion selective membrane to prepare a stream of softened water. By definition, an ion selective membrane is a membrane that selects for particular ions. Examples of an ion selective membrane are NF and RO membranes.

Al-Samadi is directed to a two-stage membrane process for purifying scale–containing water. Figure 1 illustrates the basic principles of the Al-Samadi process which are incorporated in the embodiments of Figures 2-8. Therefore, as shown in Figure 1, a stream of water containing hardness ions is pretreated and passed through a first stage membrane 7 which can be a RO or NF membrane (RO-1 or NF-1). The concentrate from the first stage membrane is sent

to and passed through a second stage membrane **11** which is also a RO membrane or a NF membrane (RO-2 or NF-2).

Although Al-Samadi discloses the use of RO and NF membranes as the first **7** and second **11** stage membranes, Applicant submits that Al-Samadi does not use RO-1/NF-1 or RO-2/NF-2 as an ion selective membrane within the meaning of the claimed invention. In this regard, Applicant respectfully requests the Examiner to consider the following discussion.

i. <u>First Stage Membrane (RO-1/NF-1)</u>

The Examiner's attention is directed to Figure 1 of Al-Samadi. Stream **6** is fed into the first stage membrane **7** (RO-1/NF-1). The purpose of the first stage is to ***preconcentrate scale compounds*** (<u>See</u> Abstract). The ***bulk of the water*** is purified by the first stage membrane stream 7 (RO-1/NF-1) via stream **14** (col. 4, lines 26). The concentrate **8** from the first stage membrane **7** (RO-1/NF-1) is the fed to the second stage membrane **11** (RO-2/NF-2). Therefore, if a softened stream of water is prepared by the first stage membrane **7** (RO-1/NF-1), that softened stream is the purified water stream **14**. The only other stream leaving the first stage membrane 7 (RO-1/NF-1) is the concentrate **8**.

ii. <u>Second Stage Membrane (RO-2/NF-2)</u>

As shown in Figure **1**, the concentrate **8** of the first stage membrane **7** (RO-1/NF-1) is fed to the second stage membrane **11** (RO-2/NF-2) to provide purification, i.e., further concentration, of the remaining preconcentrated stream (<u>See</u> Abstract). The two products of the second stage membrane **11** (RO-2/NF-2) include the purified stream **15** that combines with stream **14** to

provide the ultimate purified water. The other stream leaving the second stage membrane **11** (RO-2/NF-2) is another concentrate **12.**

iii. <u>Ion Exchange Softening Resin</u>

Al-Samadi uses an ion exchange softening resin **17** to treat the RO-2/NF-2 concentrate stream **12.** Alternatively, Al-Samadi uses chemical precipitation and filtration **23** to soften the second membrane concentrate **12.** Clearly, the use of chemical precipitation to soften water does not suggest the use of an ion selective membrane, e.g., a NF membrane, as used by the claimed invention.

Furthermore, an ion exchange resin **17** as used by Al-Samadi is composed of an ion exchange material through which a liquid passes allowing ions to be exchanged between the two substances. For example, the ion exchange method of water softening is based on the ability of the ion exchange material to exchange one ion from the water being treated with another ion in the resin. As such, an ion exchange membrane, as used by Al-Samadi, is structurally and functionally different from an ion selective membrane, e.g., a NF membrane, as used by the claimed invention. Al-Samadi does not suggest the use of an ion selective membrane to prepare a softened stream that is blended with a stream of untreated water to form a variable feed.

Therefore, for the following reasons, it is submitted that Al-Samadi does not suggest passing a first stream of water containing a high concentration of hardness ions through an ion selective membrane to form a softened water having a reduced content of hardness ions within the meaning of step (a) of the claimed invention:

- The first and second stage membranes (RO-1/NF-1) and (RO-2/NF-2) used by Al-Samadi produce purified water streams **14** and **15**, respectively, to provide the ultimate purified water **16**. The streams leaving the first and second stage membranes (RO-1/NF-1) and (RO-2/NF-2) are concentrates **8** and **12**, respectively.
- Al-Samadi uses an ion exchange resin **17** or chemical precipitation **23** to soften the concentrate stream **12** of the second stage membrane **11** (RO-2/NF-2). Use of an ion exchange resin **17** or chemical precipitation **23** does not suggest the use of an ion selective membrane to soften water as used by the claimed invention.

b. <u>The second step of the claimed process</u>:

> (b) blending the softened water with a second stream of water containing a higher concentration of hardness ions than the softened water to form a feed to a desalination system;...
>
> wherein the proportions of the softened and second stream of water forming the feed to the desalination system are varied to increase the top operating temperature of the system and increase recovery of potable water.

It is Applicant's discovery that higher top operating temperatures and increased yields of potable water are possible by using a feed comprising a variable blend of a first stream of softened water and a second stream of water having a higher concentration of hardness ions than the softened stream. The cited prior art to Hassan discloses a method of softening ***100%*** of the water that is used as the make-up or feed to a desalination system. It was unexpected, therefore, that pre-treating only ***a portion*** rather than the use of 100% of softened water did not have a negative impact on yield and the ability to achieve top brine temperatures ("TBT") of a

desalination system. Advantageously, it is possible with the claimed invention to obtain commercially variable top brine temperatures with only a partial treatment, i.e., softening, of the feed to a desalination system. This achievement is contrary to the prior art which teaches that 100% NF make-up is required to obtain an increase in the TBT.

2. **<u>NF → RO: Top Operating Temperature Benefits with the Claimed Invention</u>**

With respect to RO, it is possible with the claimed invention to advantageously increase the feed/system temperature beyond operating conditions which are currently possible. As a result of the blending step (b) of the claimed method, it is possible to perform scale free RO at higher temperatures. A higher temperature of operation permits the NF-RO system to increase production three percent (3%) in the output or flux for each 1°C increase of the system temperature. For example, a NF-RO system operating at 80°C will produce approximately 180% more permeate than a NF-RO system operating at the standard operating temperature of 25°C. Additionally, when operating in accordance with the claimed invention, the system could operate at a higher recovery exceeding 70% without the danger of scale forming in the RO membranes. This feature is particularly valuable in hybrid processes such as NF-RO-MED or NF-RO-MSF where significant amounts of waste heat is available to raise the temperature of the system.

Existing desalination membrane processes operate normally at ambient conditions, e.g., typically at 25°C. In contrast, it is possible with the claimed invention to raise the operating temperature of a membrane desalination system. The higher operating temperature results in an unexpected and advantageous improvement in flux (productivity) of the membranes. This improvement is substantiated by Figure 1 which shows data obtained from joint research

conducted by DOW-Filmtec and Leading Edge Technologies, the assignee of the subject application, in the implementation of the claimed invention. Specifically, Figure 1 confirms that there is a significant increase in flux (productivity) of 2.5 to 3 times with a Filmtec nanofiltration membrane when the operating temperature is increased from 25°C to 55°C.

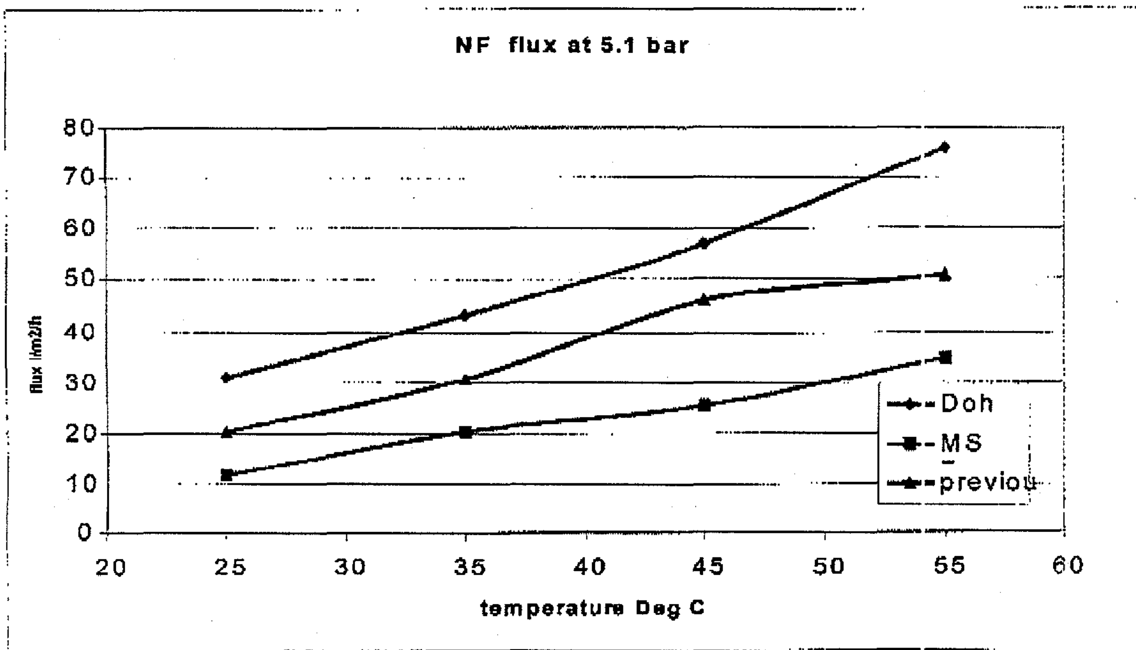

Figure 1: Flux as a function of temperature

The relationship between membrane performance and operation temperature of a desalination system is shown in Figure 2.

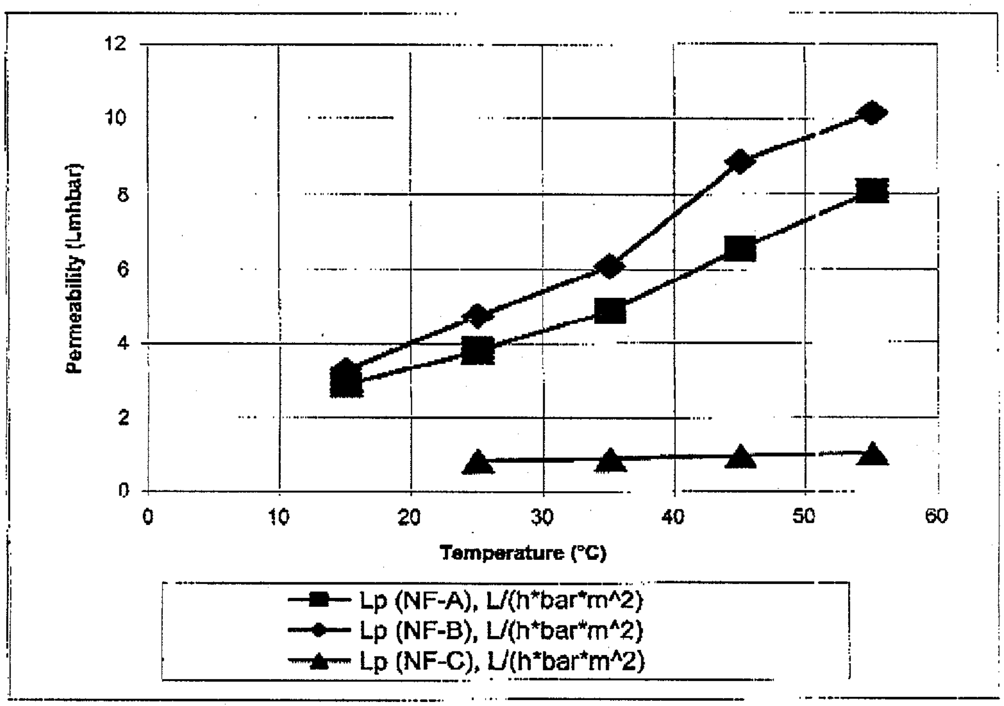

Figure 2: Passage of monovalent ions and flux as a function of temperature

Figure 3 shows data obtained from joint research conducted by Toray under direction of Dr. Masaru Kurihara and LET in the implementation of the claimed invention. Specifically, Figure 3 shows a significant positive implication of operating membranes at higher temperatures in the range of 40-45 °C in comparison to the conventional practice of operating desalination membranes at 25°C.

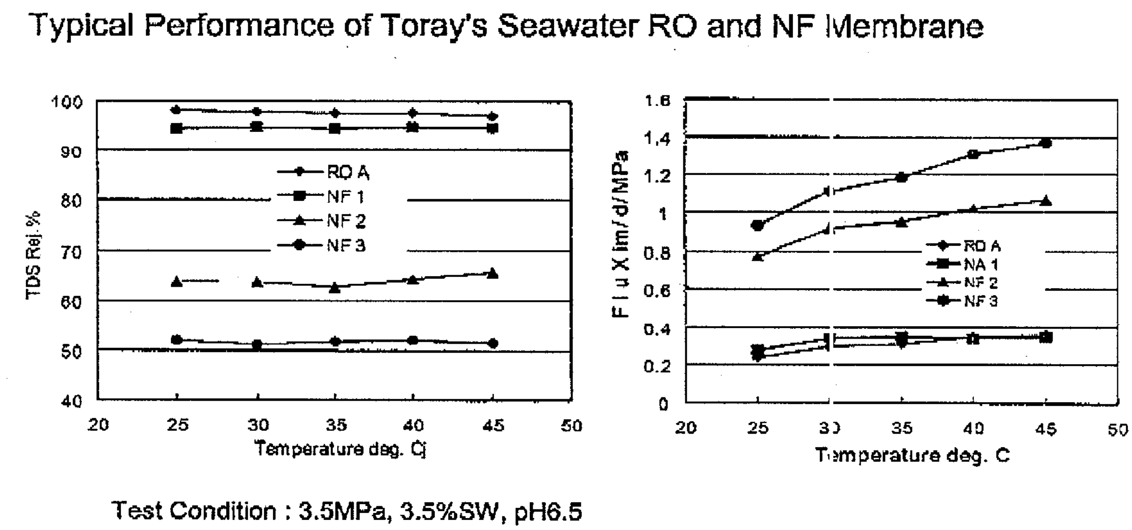

Figure 3: Performance of Toray's Seawater RO and NF Membranes

The claimed invention takes full advantage of the increase in the top operating temperature of the desalination systems. In this regard, the Examiner's attention is directed to a description of the preferred embodiment at page 4, lines 22-27. Applicant has discovered that increased operating temperature and flux is a function of a variable feed formed by blending softened and unsoftened streams of water. As the fraction of blending is increased, a higher temperature of RO and hybrid system is possible. The result is an optimally operating desalination system at lower energy and maintenance costs.

At the time the claimed invention was made, the prior art and, in general, the entire desalination industry did not recognize that partial treatment, i.e., softening a first stream, and blending the first stream with a second stream of untreated water allow for higher temperatures of operation of an RO system. Heating or preheating the first stream in connection with RO and

hybrid desalination systems are described in the specification. Furthermore, this embodiment of the claimed invention is set forth in claim 10, wherein the a stream of softened water is pre-heated by the heat of a reject stream if the desalination system.

There is no suggestion by Al-Samadi or Hassan of the importance and economic benefit of increasing the top operating temperature of a NF/RO membrane or a hybrid RO-MSF or RO-MED desalination system. To realize the benefits of increased operating temperatures, Applicant teaches that it is sufficient to soften only a partial stream of hard water and blend the softened water with the untreated portion of a stream to obtain an optimum desalination feed.

Thus, in relation to RO, the "top operating temperature" means an increase in the feed/system temperature beyond current operating conditions. In accordance with the blending step (b) of the claimed invention, it is possible to perform scale free RO at higher temperatures.. The data of Figures 1-3 , above, show that the NF membranes operating at higher temperature produce a dramatic improvement in flux. This feature is particularly valuable in hybrid processes such as NF-RO-MED or NF-RO-MSF where significant amounts of waste heat is available to raise the temperature of the system.

3. Al-Samadi does not recognize the benefits of <u>higher operating temperatures on yield.</u>

In contrast to the claimed invention, Al-Samadi discloses blending of streams of softened water with hardness containing feed streams ***for other purposes without recognizing that higher top operating temperatures and increased yields of potable water could be obtained.***

<u>Al-Samadi Purpose #1</u>: As shown in Figure 1, the first and second stage membranes (RO-1/NF-1) and (RO-2/NF-2) used by Al-Samadi produce purified water streams 14 and 15,

respectively, to provide the ultimate purified water **16**. Figures 2-4 of Al-Samadi show different embodiments wherein a portion of the purified second stage membrane permeate **15** is recycled back to the influent side of the first stage membrane **7** via stream **25**, "thus enabling further purification" using the first and second stage membrane (RO-1/NF-1) and (RO-2/NF-2) systems (col. 4, lines 45-50). As such, the different streams of water are combined for the express purpose of further purifying the second stage membrane permeate **15**.

Al-Samadi Purpose #2: Critical to Al-Samadi is the use of an ion exchange softening resin **17** or chemical precipitation **23** to provide a "softened" and "suspended solids" free second stage membrane concentrate stream **18**. As previously stated, the claimed invention is distinguished by the use of an ion selective membrane which is structurally and functionally different from an ion exchange membrane and chemical precipitation as disclosed by Al-Samadi. As shown in Figure 1 of Al-Samadi, the softened stream **18** is split into two streams **9** and **10** which are recycled and blended with hardness-containing "feed streams" to the first stage (stream 3) and to the second stage (stream **8**). Specifically, as disclosed in column 9, lines 12-23, ***a large volume*** of the softened stream **9** is added to the influent stream 3 to lower the scale formation tendency of the combined stream. At column 4, lines 27-33, it is disclosed that the softened stream **10** is combined with the first stage membrane concentrate stream **8** to reduce the scale potential of the combined feed to the second stage membrane system (RO-2/NF-2) system and to enable further purified water recovery.

The Examiner alleges, however, that Al-Samadi discloses "[t]reating only a portion of the feed to the reverse osmosis membrane unit by a reverse osmosis membrane unit…to soften the water". Applicant respectfully disagrees and submits that Al Samadi discloses feeding a sufficiently large volume **9** of the softened second stream concentrate to the influent stream **3**

(col. 9, lines 11-26). In fact, Al-Samadi discloses that the second stage recycle stream **9** can have a volume as high as 50% of the influent stream **1**(col. 9, lines 4-8). Thus, the combined stream **6** will have higher "soluble TDS" than the influent stream **1** due to the volume of recycle stream **9**. The volume of the first stage membrane **7** is further dramatically increased by the features shown in Figures 2,3 and 4 of Al-Samadi which provide recycling 90-100% of the second stage permeate **15** (col. 11, lines 36-46). This disclosure negates partial softening, as alleged by the Examiner, and destroys Al Samadi's claim that the process minimizes capital and operating cost.

Applicant submits, therefore, that the purposes disclosed by Al-Samadi for combining softened water with hardness-containing streams is proof that Al-Samadi neither recognizes the problems associated with increasing the top operating temperature of a desalination system nor the solution to the problem. Furthermore, Al-Samadi does not disclose or suggest the claimed method step (b) wherein the proportions of the softened water and untreated water are ***varied*** to increase the top operating temperature of the operating system and increase the recovery of potable water. This represents an unexpected improvement over the prior art.

Accordingly, Applicant submits that Al-Samadi is not aware of the effect which varying the percentage mix of softened water in a make-up feed has on the operating temperature of a distillation plant and the recovery of potable water. As such, this feature of the claimed invention and its advantages are not inherent, as alleged by the Examiner, in the Al-Samadi process.

Moreover, there is no suggestion by Al-Samadi that the order of the two membranes should be NF followed by RO as presently claimed. Rather, Al-Samadi discloses that the order of membranes is as follows: 1st stage membrane (RO or NF) followed by 2nd stage membrane

(RO or NF). No guidance is offered by claim 1 which is fatally indefinite and practically incomprehensible. In any event, the order of the first and second membranes in accordance with claims 1-3 of Al-Samadi is as follows: RO→RO; RO→NF; and NF→NF. There is no disclosure of the NF→RO desalination system of the claimed invention.

For all of the forgoing reasons, Applicant submits that the claimed invention is patentable over Al-Samadi:

- It is Applicant's discovery that higher top operating temperatures and increased yields of potable water are possible by using a feed comprising a variable blend of a first stream of softened water and a second stream of water having a higher concentration of hardness ions than the softened stream.
- As a result of the blending step of the claimed method, it is possible to perform scale free RO at higher temperatures. A higher temperature of operation permits the NF-RO system to increase production three percent (3%) in the output or flux for each 1°C increase of the system temperature.
- Al-Samadi neither recognizes the problems associated with increasing the top operating temperature of a desalination system nor the solution to the problem. Specifically, Al-Samadi is not aware of the effect which varying the percentage mix of softened water in a make-up feed has on the operating temperature of a distillation plant and the recovery of potable water. As such, this feature of the claimed invention and its advantages are not inherent in the Al-Samadi process

For all of the foregoing reasons, Applicants respectfully submit that the Examiner has not established a *prima facie* case of obviousness. Accordingly, withdrawal of the §103 rejection based on Al-Samadi is requested.

B. Hassan

Claims 1-3, 5, 8/1, 9/8/1, 10/9/8/1, 11/1, 12/11/1, 13-18 and 27-29 are rejected under 35 U.S.C. §103(a) as being unpatentable over Hassan.

Applicant relies on the arguments of record that Hassan does not disclose or suggest the claimed process and advantages of using a blend or variable percentage of make-up to a desalination system. ***This is true for any combination of NF and thermal distillation or RO.***

The claimed invention had previously been rejected for lack of novelty under 35 U.S.C. §102 in view of Hassan. In this regard, the Examiner's attention is directed to the Interview Summary, dated 24 June 2002, and the response submitted thereafter on 2 July 2002. The Interview Summary provides:

> Fig. 9 of [Hassan] was discussed. [Hassan] teaches using the permeate from the NF as make-up water for the desalination unit, however, ***blending the NF permeate stream with an additional water stream previous to the RO or the evaporation units is not disclosed***. [A] full response to paper No. 11 will need to be mail to the Office. An updated search will be performed upon receive the response to the final Office Action. (Emphasis added)

Applicant's response of 2 July 2002 provided a response to the §102 rejection and a summary of Applicant's discussion at the Interview. The §102 rejection was withdrawn. Thus, it has been established that Hassan does not disclose the "blending" of streams in a combined

NF-RO system. The issue is, therefore, whether Hassan suggests "blending" of streams in a combined NF-RO system.

If it is accepted that Hassan does not disclose a "blending" step but requires 100% of a softened water product as the make-up to a desalination system, then it is axiomatic that Hassan cannot suggest the use of a variable stream comprising a blend of softened water and a hardness containing stream. ***This is true for any combination of an ion selective membranes (NF) and thermal distillation or RO.*** To suggest otherwise is possible only with the benefit of impermissible hindsight.

Moreover, if Applicant's remarks and the data of record are deemed persuasive with respect to the advantages of the claimed method in increasing the top operating temperature of a combined NF-thermal desalination system, Applicant respectfully submits that the same remarks and data are equally persuasive in establishing the superior and unexpected results and, hence, the nonobviosuness of the claimed invention with respect to the combination of an ion selective membrane (NF) and RO.

Accordingly, the §103 rejection based on Hassan is improper and can only be based on impermissible hindsight. For all of the preceding reasons, withdraw of the §103 rejection based on Hassan is requested.

CONCLUSION

Upon entry of this Amendment, claims 1-18 and 27-29 are pending. Applicants respectfully submit that claims 1-18 and 27-29 are directed to patentable subject matter. Accordingly, Applicants request allowance of the claims.

Authorization is hereby given to charge any fee in connection with this communication to Deposit Account No. 23-1703.

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Respectfully submitted,

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